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ENHANCING AND ENABLING CRITICAL THINKING IN E-LEARNING

Bachelor's thesis

Apollonkatu, Helsinki
26.09.2018

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Aalto University School of Science Information Networks		BACHELOR'S THESIS ABSTRACT
Author: Salla-Mari Saanio		
Title of thesis: Enhancing and enabling critical thinking in e-learning		
Number of pages: 25 (+3)	Date:26.09.2018	Language: English
Major: Information Networks		Major subject code: SCI3026
<p>The objective of this thesis is to form an understanding of how critical thinking appears in e-learning and how it can be enhanced and enabled. Three research questions were formulated. The research question are: What approach or approaches could be used for studying the implementation of critical thinking in e-learning? How can critical thinking be enabled and enhanced in e-learning? Which aspects should be considered when implementing these ways of enhancing and enabling critical thinking to e-learning context?</p> <p>Ten learning strategies are recognized: rehearsal, elaboration, organisation, planning strategies, monitoring strategies, regulating strategies, time management, environment management, support of others and effort management. These learning strategies are divided to three types: cognitive, metacognitive and recourse management strategies.</p> <p>From cognitive strategies organisation and elaboration strategies are the most relevant in enhancing critical thinking. From metacognitive strategies monitoring strategies can be used to enable and enhance critical thinking.</p> <p>Learning tools that use elaboration and organisation are most relevant for critical thinking. The Socratic method, argument mapping and concept mapping tools are examples of these and are discussed in detail, in relation to critical thinking and implementation to e-learning. In more general terms they are visualization and discussion tools.</p> <p>Aspects that should be considered with communication in e-learning tools are whether the communication is to be synchronous or asynchronous, and whether it is in written or spoken form. In the case of the Socratic method, as well as other possible methods that present the learner with questions, the types of questions need to be considered. Commonly among all kinds of e-learning tools, the need for new tools and effect on motivation should be considered.</p> <p>The thesis presents a structure: "learning strategy -> learning activity -> learning tools -> implementation of the learning tools" as one theoretical background for studying critical thinking in e-learning.</p>		
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Keywords: e-learning, critical thinking		

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1 Introduction

1.1 E.-learning is growing

The e-learning industry is and has grown dramatically during the past twenty years (Pulido, Villamil and Tarazona, 2017). E-learning studies have often focused on studying e-learning tools as well as e-learning materials which are used with electronic tools. Examples of popular themes in e-learning studies are effectiveness of learning tools, the speed of learning, learning results and the motivation of the learner. Another aspect which has been studied is the learning experience, which is often related to one or more of the themes mentioned above. In general, good experience correlates with good learning results. The results from e-learning studies have been often compared to the results in traditional learning.

However, there are more aspects to learning. Learning tools and technologies which learners use do not only assist learners in learning new content, but also in gaining higher level cognitive skills. (Laurillard, 2002:150). Critical thinking is one aspect of learning which requires higher level cognitive skills, and it will be addressed in this research.

1.2 Critical thinking is more important than ever

The importance of critical thinking increases in e-learning for many reasons. One reason is that in e-learning learners often use sources that are not determined by teachers, but which they have independently found online. This can result in the learners to be more likely to use materials from less reliable sources and with lower quality. Simultaneously, with the use of internet, it is easier than ever to find large amounts of information about the topics, including alternative information and information from alternative sources. This means that learners have a possibility to question the information they are offered more easily than before.

In addition, the internet offers the possibility to find supporting material for one's own views and arguments more easily than before. The Internet is so full of material that one can find material that supports nearly any kind of a view, including controverting views. This means that one can find material supporting their own views, which can make people less critical and more firm about their own beliefs. For this reason, for modern day learners critical thinking in relation to their own views is an extremely relevant skill, in addition to thinking critically about the material that is studied. Since critical thinking is highly relevant in e-learning, it is also relevant to examine how critical thinking appears in e-learning. This includes considering the tools or tasks that help learners to perform critical thinking in e-learning. In this paper, we will examine how critical thinking appears in e-learning and how it can be enhanced and enabled.

1.3 Research questions

The aim of this study is to find out how critical thinking can be enabled and enhanced in e-learning. There is no, commonly agreed-on, best way to study critical thinking in e-learning. Thus, the study will firstly consider the theoretical background of learning and critical thinking, in order to form an approach or approaches for studying how critical thinking can be enhanced and enabled in e-learning.

The first research question focuses on the possible approaches for studying critical thinking in e-learning and is formulated as:

1. What approach or approaches could be used for studying the implementation of critical thinking in e-learning?

By an approach we refer to the theoretical framework, which can be used as a basis on which the study of critical thinking in e-learning can be built.

However, the research is not limited to naming a suitable approach or approaches for studying critical thinking in e-learning. The research will also aim at naming different ways of implementing critical thinking into e-learning and aspects which should be considered when using these ways. The second research question is formulated as:

2. How can critical thinking be enabled and enhanced in e-learning?

The aim is naming different ways that enable or enhance critical thinking in e-learning. These ways can be practical protocols, methods or tools, and will be discussed as a part of answering the first research question, and thus cannot yet be fully defined.

3. Which aspects should be considered when implementing these ways of enhancing and enabling critical thinking to e-learning context?

E-learning is different from traditional learning in many ways, and has special features, such as mobility, flexibility, availability and non-time dependency. With the third research question we also want to study how the different ways of enhancing and enabling critical thinking actually suite e-learning. The third research question can be addressed after the second one, because first the ways of enabling and enhancing critical thinking need to be recognized.

1.4. E-learning environments and tools

This research focuses only on learning in e-learning environments. An e-learning environment is the online or offline environment, where the learning process is performed with the help of electronic educational technology. These educational technologies can include multimedia technology, both online and offline technologies, as well as mobile technologies. This study does not focus on certain types of e-learning environments or educational technologies.

Different tools can be used to enhance critical thinking in e-learning environments. By tool we refer to instruments and devices which aid in accomplishing tasks following Jonassen and Carr in their definition of tools. (Jonassen and Carr, 2000 cited in Grogan, 2011) Different learning tools use different, sometimes several, learning strategies which can be carried out using different learning activities. Learning activities are tasks that the learners perform and which can involve usage of tools. In order to understand how the learning tools work, learning strategies need to be understood first. Studying different learning strategies is the first step in studying a possible model for looking at critical thinking in e-learning.

2 Learning strategies

Different learning strategies can be used to assist learning. A taxonomy of learning strategies which we will be looking at in this section has been created in the following way by McKeachie et al. (1986):

- Cognitive Strategies: Rehearsal, Elaboration and Organisation
- Metacognitive Strategies: Planning, Monitoring and Regulating
- Resource Management: Time management, Environment management, Effort management and Support of Others

This division into cognitive, metacognitive and management strategies has been used in research in various fields of science. The division was not created for e-learning purposes and is more than thirty years old, but can and has been applied to e-learning. It remains highly relevant and is applied by modern research.

2.1 Cognitive strategies

The basic cognitive learning strategies are rehearsal, elaboration, and organisational strategies. These strategies aim at bringing information into the working memory. These strategies can be applied at different levels of complexity and include activities that vary in complexity. The complexity of the learning strategy depends on the learning task, since different learning tasks aim at different outcomes (p 25-27, McKeachie et al., 1986). For example, some tasks aim at long-term results, whereas some aim at short-term results. Similarly, some learning tasks require deep understanding of complex subjects, but other learning tasks, such as remembering terminology, do not. In this way the learning tasks also vary in complexity, and cognitive learning strategies can aim at learning of any level of complexity.

Organisation is a cognitive learning strategy that refers to the learners' activity of organising new information (McKeachie et al., 1986) and the ability to highlight main points during learning (Effeney et al., 2013 cites at Broadbent & Poon, 2015). This can help with understanding the bigger picture and connections in the information that is to be learned. It can also help with grasping the most essential parts of what is to be studied. It can include drawing charts and tables, and clustering; organising words into different categories (Broadbent & Poon, 2015).

Elaboration strategies aim at helping the learner gain a long-term memory of the subject that is learned; elaboration methods include paraphrasing, summarizing and creating analogies (McKeachie et al., 1986). With analogies, the learner creates connections between different things that for the learner at first might feel like having nothing in common. A Long-term memory is gained by combining the new information to something that the learner already knows.

Rehearsal means learning by repetition, and works by bringing information to the working memory. This can be achieved in different ways; for example, by highlighting important parts of a text, rewriting it or reading it aloud. This does not help with understanding connections in the information that is to be learned in the way organising does, but focuses the attention of the learner to details. They should be combined with other learning strategies to efficiently integrate new knowledge to long-term memory. (McKeachie et al., 1986)

2.2 Metacognitive strategies

Yukselturk and Bulut refer to metacognitive strategies as the “awareness to monitor, plan, and regulate learning” (2007, cited in Broadbent & Poon, 2015, p.2) Metacognition can be explained by two types of relations it can have on cognition. The first relation is awareness and understanding of cognition and the second is control and regulation of cognition. Metacognitive strategies include planning, monitoring and regulating strategies (Brown et al., 1983; Flavell, 1979).

Planning aims at helping the learner with processing information and understanding which learning strategies and methods they want to use. This can be achieved by setting goals, skimming and choosing where to focus. In addition, planning helps the learner with being ready and alert to learn, by bringing relevant prior knowledge to active memory. (McKeachie et al., 1986)

Monitoring is defined as a learners’ activity of analysing how the learning progresses. Monitoring activities include attention tracking and self-testing while reading a text to insure comprehension of the material. These and other monitoring activities assist the learner in understanding the material and combining it with prior knowledge. (McKeachie et al., 1986)

Regulative strategies are strongly linked to monitoring strategies, since monitoring offers information that can be used to regulate behaviour. Together, monitoring and regulating help the learner to adjust learning activities, such as reading and writing, to an appropriate level on different aspects, such as speed and detail. In this way regulation helps the learners with learning, by making them develop their behaviour and own learning process. Regulating strategies include adjusting reading rate, re-reading, rewriting and test-taking strategies. (McKeachie et al., 1986)

2.3 Resource management strategies

Learning always occurs in an environment and requires some resources. Resource management strategies help the learner to fit into the environment, shape the environment and use the resources needed for learning in an optimal way (McKeachie et al., 1986).

Time management is scheduling when to study and for how long, and it includes management on different levels (McKeachie et al., 1986). For example, it includes management of how to plan long time periods (e.g. months), as well as time-management of study sessions lasting just a few hours. Metacognitive activities of planning and regulation are linked to time management, since schedules set by time-management are regulated and should be changed when needed. If the initial schedules are not perfect, regulation and planning need to be considered.

Studying always occurs in an environment. Usually, learners can choose from different environments and modify the space they are in. This can mean, for example, going to a library, cleaning a room before studying or putting music on. In an ideal study environment, the learner can concentrate their attention on learning, but the qualities of this environment vary individually. Modification of and changing these study environments is called environment management. (McKeachie et al., 1986)

Support of others can be seen as being part of the study environment. Learners need help from others in learning. This can be help from teachers, other learners or someone else. As a regulative strategy, the learner needs to know when to ask for help and when not to. This requires understanding of the learner's own limitations. The learner must also regulate where to ask for help, since different people can help with different things. (McKeachie et al., 1986)

Effort regulation is defined as adjusting the amount of effort used. Effort management strategies help learners to perform effort regulation. This includes both persisting when faced with challenges and using less effort when appropriate. Effort management learning strategies include self-reinforcement, persistence, attribution to effort and self-talk. (McKeachie et al., 1986)

3 Critical thinking

3.1 Definitions

Critical thinking is one aspect of learning. There are numerous definitions for critical thinking. According to Dewey, who is a pioneer on the field of critical thinking as well as philosophy of education and educational pedagogy in a broader sense, critical thinking aims at objective judgements based on facts. For him this active process of critical thinking suspends judgments, maintains healthy skepticism and exercise an open mind (Dewey, 1933).

One of the most foundational distinctions that have been made in defining critical thinking, is dividing critical thinking to activities and “dispositions” of critical thinking. By this distinction critical thinking can be seen firstly as a combination of different practical skills, aiming at gaining objective judgements like “analyzing arguments, judging credibility of sources, identifying the focus of the issue, and answering and asking clarifying questions” and secondly, as a “dispositions” meaning critical attitude or point of view. (Ten Dam & Volman. 2004) The second definition would leave open how critical thinking is carried out, but focuses on the metacognitive aspect of thinking about thinking.

In this research we will take the view of critical thinking as an activity. It should be noted that there is a relationship between critical thinking as an activity and as a point of view. Critical thinking does not have to be either one or another. Oppositely, a critical point of view often leads to activities of critical thinking.

Critical thinking aims at objective judgements, but these judgements can be judgements of various aspects. Thus, critical thinking can be directed towards many different things, for example at the learners’ own thinking, arguments and argumentation of others or reliability of sources. Critical thinking can also be directed at various aspects simultaneously, and critical thinking of one aspect makes critical thinking of other aspects more probable.

There are also similarities among different theories of critical thinking. Constructivism and cognitive skills are two things that are mostly common among different theories. Constructivism means that learners acquire and build knowledge and derive meaning from experience with prior knowledge. Cognitive skills are skills that require cognitive thinking, such as analysing, interpreting, evaluating and metacognitive skills. Metacognitive skills that are commonly named as part of critical thinking are reflection and regulative skills. (Grogan, 2011)

Thus, whilst there are differences in these definitions of critical thinking, there are also some common themes. For instance, most accounts agree that critical thinking is active and constructive, involving persistent effort in the construction of arguments or beliefs, artefacts or actions. Secondly, critical thinking requires the use of cognitive skills, such as analysing, interpreting and evaluating. In addition, metacognitive skills, such as the capacity to reflect on and regulate our actions, are now seen as an important aspect of critical thinking.

3.2 Dimensions of critical thinking

Critical thinking can be broken down to smaller (parts or) dimensions. Sometimes all of the dimensions of critical thinking are taking place, but not always. This also means that studies that examine only some dimensions of critical thinking might not actually connect the dimension of critical thinking to critical thinking as a broader concept. For these reasons, understanding the different dimensions of critical thinking can help us see when is critical thinking occurring, and by doing so help us study how to enhance or enable critical thinking. There are various theories of the different dimensions of critical thinking. We will briefly present two different ways of dividing critical thinking to different dimensions.

Critical thinking has been considered having five dimensions: hypothesis identification, induction, deduction, explanation and evaluation. Hypothesis identification is the recognition of different statements, ideas and assumptions behind the hypothesis of an argument. Induction is reasoning from smaller to bigger scale. By induction, generalisations are formulated based on a specific case or cases. Deduction is reasoning from bigger to smaller scale. By deduction a problem is solved by reasoning from general statements. Explanation is clarifications of causes, context and consequences of different parts and dimensions of the argument. Evaluation is a criterion based objective analysis of the outcome and the steps of the argument. (Kong. 2015)

Another way of dividing critical thinking is to following results from Delphi panel, which was an interactive panel of experts, who studied the role of critical thinking in educational assessment and instruction. They divided critical thinking to six dimensions: interpretation, analysis, evaluation, inference, explanation and metacognition. Evaluation and explanation are common among this division and the division that was already explained above in the frame of the division to five dimensions. The rest four dimensions will be explained and smaller parts, “sub-skills” will be named for all the dimensions, following Delphi panel. Interpretation is understanding and expression of what is on hand and its sub-skills are “categorization, decoding significance, and clarifying meaning”. Analysis is the identification of relationships within the target of critical thinking and the sub-skills are “examining ideas, detecting arguments, and analyzing arguments into

their component elements”. Inference is identification of necessary elements for the conclusion to be valid and the sub-skills are “querying evidence, conjecturing alternatives, and drawing conclusions”. Metacognition is self-regulation, which in this context means learners’ examination of own cognitive tasks. The sub-skills of metacognition are “self-examination and self-correction”. (Facione, 1990)

4 Critical thinking in e-learning

In this chapter we will examine different ways for enhancing and enabling critical thinking in e-learning. We will first discuss mindtools, which is a broader category for tools that enable critical thinking in e-learning. In this context tools are instruments and devices that aid in accomplishing tasks. (Jonassen and Carr, 2000 cited in Grogan, 2011) Then we will have a look at the Socratic method, which is a discussional method that enhances critical thinking. After that, we will discuss mapping tools, which are learning tools that enhance critical thinking. We will also discuss the implementation of the Socratic method and mapping tools to e-learning context. This helps us to answer the third research question: “Which aspects should be considered when implementing these ways of enhancing and enabling critical thinking to e-learning context?”

This means that many potential tools for enhancing and enabling critical thinking in e-learning need to be left without further investigation on the resources of this research. Some examples of other methods that could be further investigated in the similar manner as the chosen ones are online discussion, small group activities, debate, reflection activities and the four question technique.

4.1 Mindtools

One concept that has been used for investigating critical thinking tools in learning is the concept of mindtools. Jonassen and Yueh describe these tools which he calls mindtools as “applications that, when used by learners to represent what they know, necessarily engage them in critical thinking about the content they are studying“. (Jonassen & Yueh, 1998, p.24) Many of these mindtools have been researched, theorized and discussed also in other context, without actually calling them mindtools. Jonassen’s theory of mindtools is pragmatic and well applicable to different learning contexts, including the e-learning context. Jonassen divides mindtools into five groups: semantic organization tools, dynamic modeling tools, information interpretation tools, knowledge construction tools, and conversation and collaboration tools (Jonassen & Yueh, 1998). According to Grogan, cognitive tools according to this taxonomy would be Semantic Organisation, Visualisation, Knowledge Construction and Modelling tools (Grogan, 2011). Different mindtools enhance critical thinking in different ways and they touch different dimensions of critical thinking. Next, we will have a closer look at a few of the mindtools that are most relevant in the framework of this study.

4.1.1 Semantic organization and semantic organization tools

Organisation is a cognitive learning strategy that refers to the learners’ activity of organising new information. This can help with understanding the bigger picture and connections in the information

that is to be learned, which is essential for critical thinking. It can also help with grasping the most essential parts of what is to be studied. It can include drawing charts and tables, and clustering; organising words into different categories (J. Broadbent , W.L. Poon, 2015). Semantic organization is how people make sense of the world by semantic relationships among different components of the world. It is how we organize what we already know, as well as new information that they are learning. Semantic organization tools help learners with this task. Many different tools can be used as semantic organization tools, Jonassen and Yueh introduce database management systems and semantic networks as the best-known ones (Jonassen & Yueh, 1998).

4.1.2 Information interpretation tools

Information interpretation tools help learners to process information they are faced with. Jonassen and Yueh pointed out that the volume and complexity of information is growing and thus learners need tools to process and access this information. More than twenty years later, this still is the case, and information interpretation tools have a lot to offer for critical thinking in e-learning. (Jonassen & Yueh, 1998)

Visualization tools help learners with the conflict of us receiving information visually, but not being able to output ideas visually in a cognitive manner. Visualization tools help learners to represent their mental images of ideas, until a certain extent. An example of a visualization tool would be the way mathematical formulas or chemical structures can be visualized using different visualization tools.

4.1.3 Conversational e-learning tools

Many recent theories of learning focus on the social aspect of learning. People learn for a great part by discussing with others, so when sharing own thoughts and listening to the thoughts of others, and often this does not include teaching. Discussion includes asking and answering questions, and asking and answering questions that are challenging or clarifying are a “skill” of critical thinking (Ten Dam & Volman, 2004).

There are many types of tools that can enable conversation remotely and online. These tools vary on the way the conversation is held. One of the main distinctions is whether the conversation is carried out in written or spoken form. Written conversation can happen in chats, letters, posts or other forms. Another main distinction is whether the conversation happens synchronously or asynchronously. Synchronous communication means that the participants are participating actively at the same time. In e-learning context this could be via video calls or chats, for example. Asynchronous communication includes a time lag, and the participants are not always active at the

same time. Posting or emailing would be examples of asynchronous communication in e-learning context.

4.2 The Socratic method

The Socratic method aims to promote critical thinking of learners. Through the Socratic method, critical thinking can be targeted at learners' own thoughts and opinions, as a part of the learning process. This method is used after the learner has provided an answer to a question and is intended to help learners critically evaluate their own answer.

4.2.1 Usage of the Socratic method for enhancing critical thinking

Merritts and Walter (n.d.) provide guidelines on how the Socratic method can be used by teachers. One of the guidelines is to “promote critical thinking by avoiding questions that only require a “yes/no” answer” (Merritts and Walter, n.d. cited in Ertugrul and Inan, 2009). This is because questions that can be answered “yes/no” do not challenge the learner enough to enhance critical thinking. There are different kinds of questions that can enhance critical thinking; a key aspect in all of them is that they are not only “yes/no” questions. Table 1 below, is based on six types of Socratic questions, and illustrates different kinds of questions that can be used in the Socratic method and how they relate to critical thinking (Paul, R. and Elder, L. 2006)

Table 1 - Different types of questions and their relation to critical thinking

Type of question	How it relates to critical thinking
Clarifications	Clarification questions should be answered with explanations. This helps the learners to examine the logic and validity of reason behind their answers. Interpretation - clarifying meaning
Probing assumptions	Probing assumptions questions aim at questioning the very basis on which the answer is built on. This means questioning basic beliefs and assumptions and raises the question on which basis is their answer given. Analysis - analyzing arguments into their component elements.
Probing reasoning and evidence	These questions can be used to make the learner consider their explanations. Often asking for examples the learner need to dig deeper into their reasoning. Evaluation - assessing claims and assessing arguments.

Analysing perspectives	Questions can aim at making the learner consider other perspectives, even opposite ones. By considering other perspectives the learner can find limitations and weaknesses from their own answers and logic. Inference - conjecturing alternatives,
Probing consequence	These questions aim at helping the learners understand effects and consequences of their answers. This can help to find weaknesses or problems with logic of the answers. Evaluation – assessing arguments.
Questioning the question	By making the learner consider the reason for asking the question in the first place. This can help the learner find problems with the foundations of their answers, and reconsider if they really answered the question.

With different kinds of questions, we can help the learner to focus on developing different aspects of the answer. Understanding the effects of different types of questions on the learners' further analysis of their own answer, helps to create e-learning with purposeful questions. Critical thinking includes re-thinking of learners' own answers. This can be considered as the evaluation part of the five dimensions of critical thinking. The Socratic method helps, at times even forces, the learner to evaluate their own argumentation as well as the outcome of it and in this manner purposefully chosen questions can be an effective tool to enhance critical thinking in e-learning (Whiteley, 2014).

4.2.2 Implementation of the Socratic method to e-learning

One of the major challenges of the implementation of the Socratic method to e-learning context is knowing which questions are suitable for the learner and the argument on hand. Avoidance of questions that are vague, ambiguous, or too advanced for a learner is one key factor for a successful use of the Socratic method. (Merritts & Walter, n.d.) However, on e-learning platforms this is often challenging, since teachers often do not have eye contact with the learner and thus it is harder to know if the student has understood the question (Whiteley, 2014. p. 67). In order for the Socratic method to be successful, the learner must answer questions that are suitable for them. The method aims at a situation where all the questions asked from the learner, enhance their critical thinking. Often this is not the case, and it is enough that some of the questions enhance critical thinking.

Discussion boards are possible platforms for implementation the Socratic method. Discussion on them usually happens over time, so the communication is asynchronous. This creates another challenge for implementing the Socratic method to e-learning. The temporal separation of the questioner and learner affects the dynamics of the question asking and answering, which can be

called discussion. Temporal separation can be challenging for the learner, since after time has passed from providing the answer, the learner might not clearly remember how they reasoned and concluded their answer. This means that, on the one hand, temporal separation makes it harder for learners to analyse their own reasoning, since they might not remember it clearly. On the other hand, temporal separation gives the learner more time to think about their answers and structure their thoughts.

A third challenge that the Socratic method faces, and one which is highly relevant also in e-learning context, is the motivation of the learner. Learners may feel frustrated when answering many questions about their own answers. For the learner, analysing their own arguments might feel like not moving forward with the developing their answer and learning itself (cf. Twibell, Ryan, Hermiz, 2005). Good overall motivation for the learning progress can help with this issue, as well as feedback from the answers given to the questions. It should be noted that user friendly interface helps learners to keep up their motivation, whereas bad user interface design can be unmotivating. Within the scope of this research user interface design will not be discussed.

4.3 Argument mapping and concept mapping

4.3.1 Argument mapping

Argument mapping is a visual representation of how a text-based argument is structured. It is a flowchart composed of boxes and arrows (van Gelder, 2003), like seen in the Figure 1 below. Typically, this means that the argument includes premises, reasoning and a conclusion. The key point is to separate different claims of an argument from each other. This helps the learner to see the logical structure of an argument. In argument mapping, the learner groups information and presents it in a hierarchical manner; these two activities make it easier to organise the information in the working memory and long-term memory and by doing so enhance critical thinking of the learner.

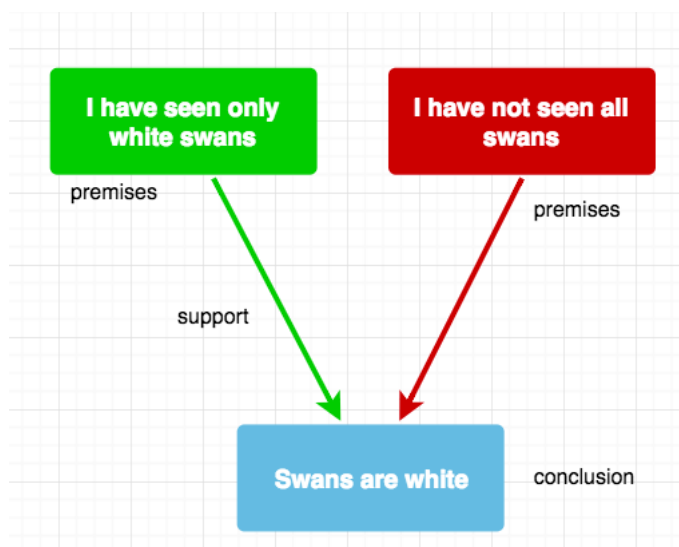


Figure 1 - Argument map

4.3.2 Usage of argument mapping for enhancing critical thinking

Analysing text-based arguments often requires switching of attention from one part of the text to another, and this can be challenging for cognition. Argument mapping helps with this issue by making the analysis of the argument lighter for the cognition. This is done by structuring the argument in an easily comprehensible form, and thus liberating cognitive capacity for the analysis of the argument. In practice, argument mapping helps the learner to name the assumptions behind the argument, and research has shown that it enhances critical thinking (Dwyer, C. P., Hogan, M. J., & Stewart, I., 2012).

Text-based representations of arguments are often rather lengthy. According to Monk (2001), students often have difficulties with assimilating text-based arguments as they can be “maze-like”, making the key points hard to grasp. Often the whole argument cannot be summarised into one sentence. This means that reading through text-based arguments often requires the learner to go back in the text to understand the flow of the argument. In such cases, the learner must remember and understand what was said in earlier parts of the text in order to understand the later parts. This can be a heavy task for the short term-memory of the learner. If the argument structure of a text-based argument is not understood by the learner, there is less room for critical thinking. Argument mapping helps learners with this issue by making the argument easier to grasp and lessening the cognitive load, and by doing so makes critical thinking possible.(Dwyer, C. P., Hogan, M. J., & Stewart, I., 2012)

Argument mapping also helps with learning by using different cues to group together different parts of what is to be learned, and this helps the working visual memory of the learner. (Woodman, G. F., Vecera, S. P., & Luck, S. J. 2003). According to Jiang, Olson and Chun (2000), the working memory benefits from having multiple different organising cues at the same time, and argument mapping

offers tools for doing this. There can be different types of cues: colour, shape or size, for example. Grouping can also help the learner to see the argument in a new way. Simply looking at the same argument in different ways can help the learner to re-evaluate it, and by doing so, enhance critical thinking.

Different dimensions of critical thinking can also be used to examine critical thinking in argument mapping. Interpretation was said to include categorization, and argument mapping makes this possible. For example, all parts of an argument that have something in common can be coded with the same colour. The coding can be based on anything that is relevant for the purpose. As an example, the coding could be for the methods used to conduct the part of the argument on hand. This makes it possible to categorize the arguments in a visual form, which is one “sub-skill” of interpretation dimension of critical thinking. (Facione, 1990). Looking at the analysis dimension of critical thinking which we discussed before, “analyzing arguments into their component elements” is something that argument mapping can help with. In addition, looking at the explanation dimension of critical thinking “stating result” can be performed using argument mapping.

4.3.3 Concept mapping

Concept maps are graphic organisers, meaning that they visualize the structures of abstract concepts. They show relationships between concepts and usually include only a small amount of text, often key words only. Concept maps usually have the written information displayed in boxes or circles and labeled arrows demonstrate the relationships between concepts. (Cañas & Novak, 2008)

There are different types of concept maps, including chronological/hierarchical, flow charts, spider, and systems maps. The difference between them is which kind of relationships they visualize. Spider map has one central concept, and all other concepts are represented in relation to that central concept. Hierarchical concept maps represent the hierarchies between concepts, whereas chronological concept maps represent the chronological order of concepts. Flow charts visualize concepts in a linear fashion. System maps represent more complex structures with various inputs and outputs. (Harris and Shenghua, 2013, p 208) Below figures 2-4 show different

types of concept maps that have been created with a free online drawing tool called Draw.io.

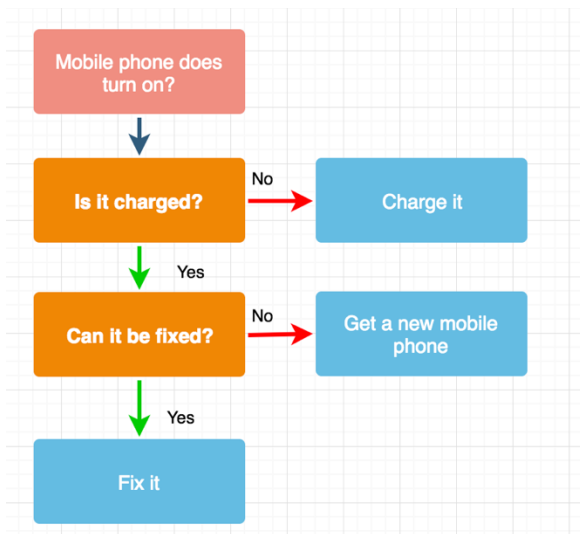


Figure 2 - Flow Chart

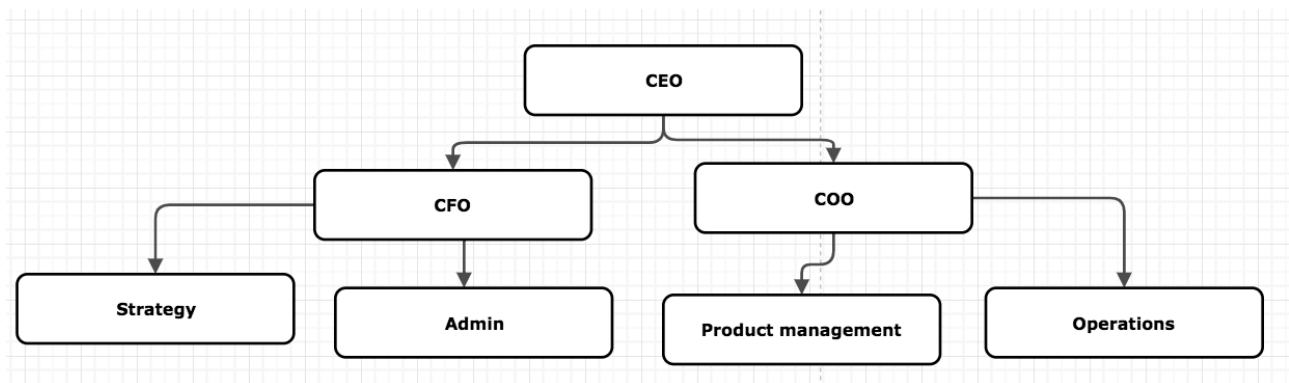


Figure 3 - Hierarchy map

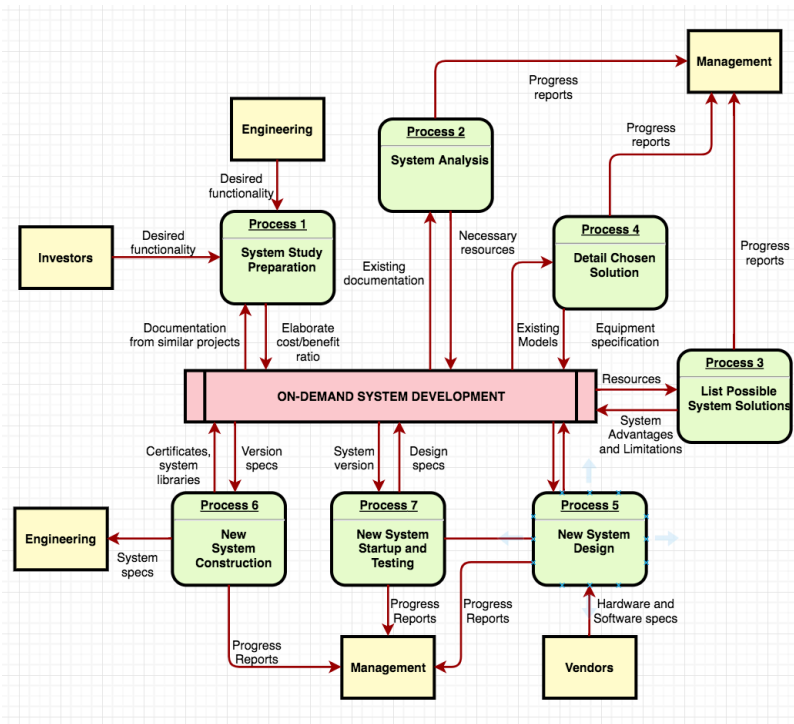


Figure 4- System map

4.3.4 Usage of concept mapping for enhancing critical thinking

Concept maps have been largely developed by Novak on the basis of theories of meaningful learning and assimilation, which are linked to critical thinking and help us understand, how concept mapping can enhance critical thinking in learning. All learning is not meaningful learning, but for meaningful learning to take place it is required that the concepts that are learned are meaningful for the learner and that the learner is capable of integrating the new knowledge to prior knowledge in a meaningful way (Keengwe, J., Onchwari, G. and Wachira, P., 2008.). Integrating new knowledge to prior knowledge is also related to the constructivist learning theories. Meaningful learning establishes links and relationships between the concepts that are to be learned, whereas rote learning is not able to to establish relationships between concepts (Cañas & Noval, 2008). The activity of making a concept map forces the learner to interpret, analyze and evaluate the logic behind the concepts they are learning (Chabeli, M., 2010, p.89).

System concept maps are most relevant to the aspect of critical thinking from the types of concept maps that were mentioned above. This is because they are not as limited as the other types of concept maps are. Hierarchical and chronological concept maps are the most disadvantageous for critical thinking, since they do not include interrelationships between concepts and only use a certain aspect (hierarchy or chronology) to represent the relations (Harris and Shenghua, 2013, p 208).

4.3.5 Implementation of argument and concept mappings to e-learning

Argument mapping and concept mapping can be practices without electronic devices, simply with a pen and paper, but electronic tools are often used. Argument mapping and concept mapping do not always require special e-learning tools designed only for argument mapping or concept mapping purposes but can easily be practiced with other drawing tools. There are also many tools specific for argument and concept mapping, and these tools usually guide the learner with creating the visual representation of the argument, and thus help the learner with mapping, if they were not familiar with it beforehand. Below, in Figures 5-7, there are three pictures of an online argument mapping tool called Rationale. The first picture shows the home view, which is used when creating the argument map. The second picture shows an example of an argument map available in the tool. The third picture shows a “Quick Start” map with instructions that the user can use to build their own argument map.

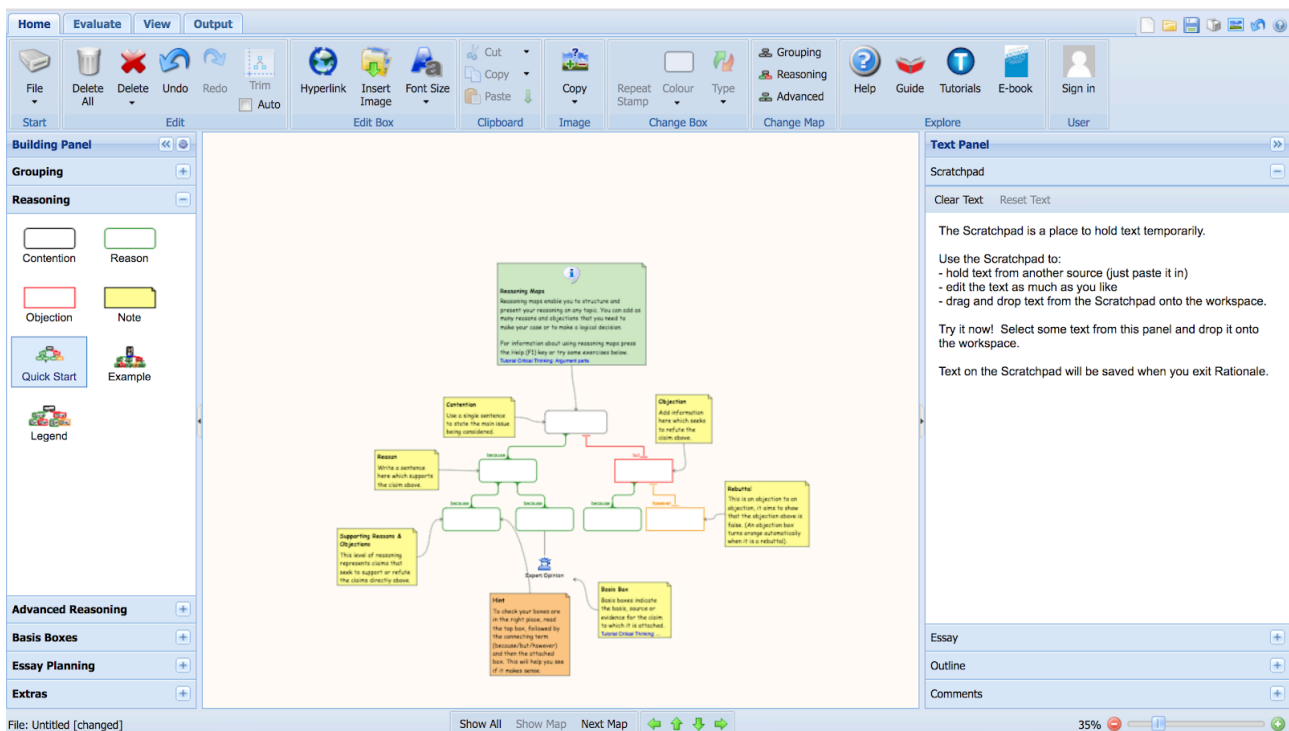


Figure 5 - Home view

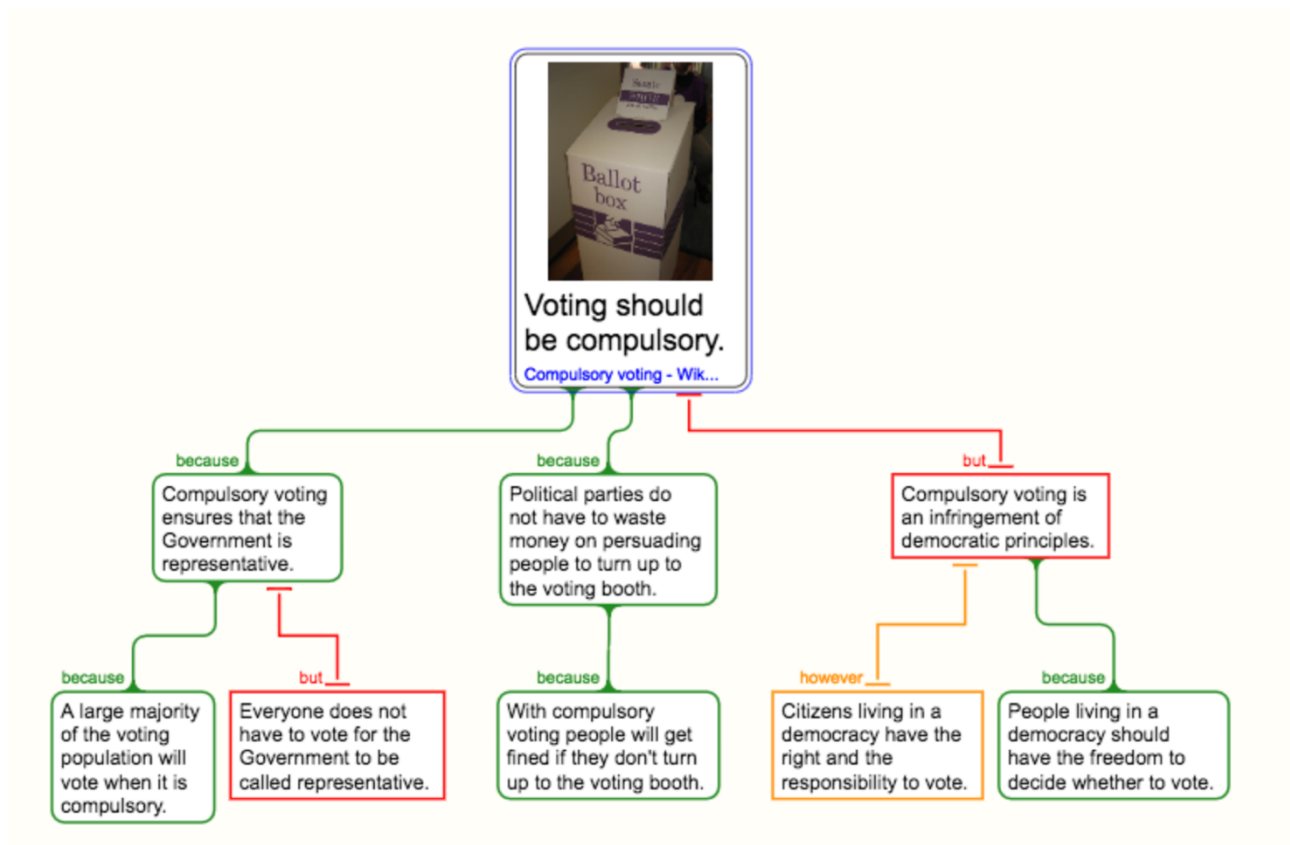


Figure 6 - Example argument map

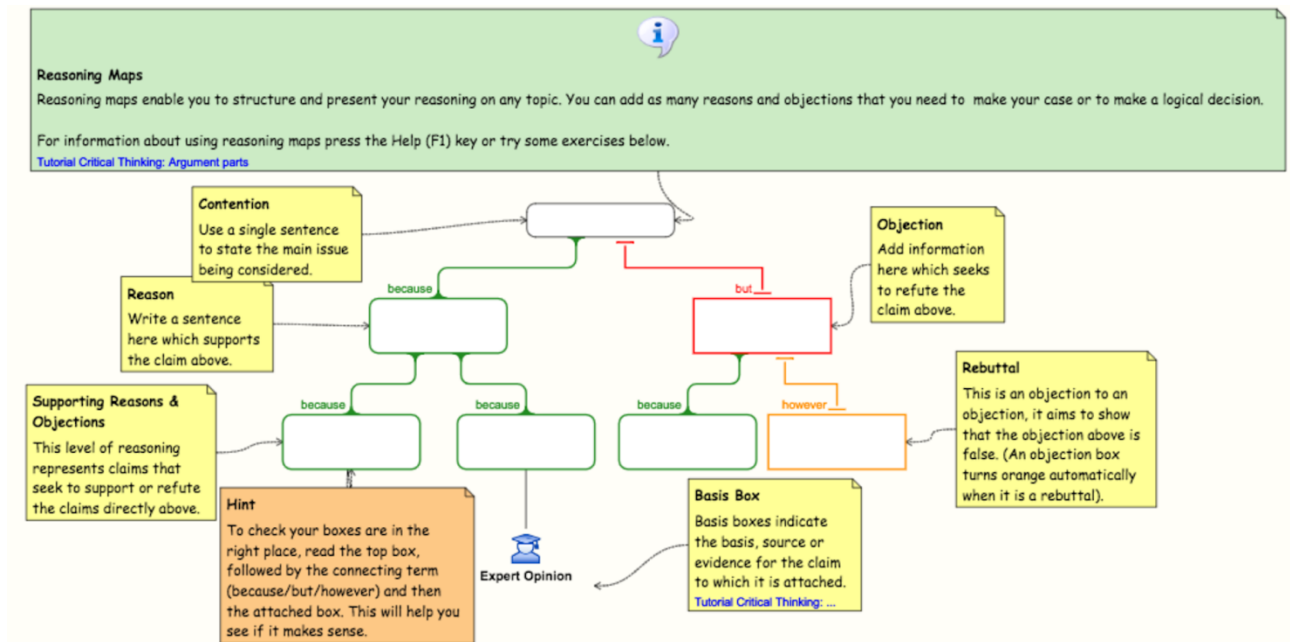


Figure 7 - "Quick start" map

Many argument mapping tools are free and online. The fact that mapping is usually done on electronic tools, often on a computer or pad, makes it easier to implement it to e-learning context.

Mapping as an activity does not necessarily need to change in any way when it is implemented to an e-learning course but can be practiced in the same way as it was on a traditional course.

Usually e-learning platforms themselves do not yet offer an argument-mapping tool. This means that the learners usually have to use one program or application more than they would, if the course did not include the use of argument or concept mapping. In many cases, the learners have to learn how to use a new program or application. However, this is not necessarily the case, since learners might already be familiar with mapping tools, or they might be able to use other tools, like drawing tools, which they already are familiar with. Adding more tools to an e-learning course can be a challenge, since it might be challenging and de-motivating for learners to learn to use new programs. Also, it can complicate the structure of the course, and confuse learners.

Argument maps should include many points, and this often requires a lot of space on a physical screen or paper. Argument maps work at their best when the whole argument map can be seen in one picture, meaning that scrolling is not needed. Mobile devices are often too small to show an entire argument map with readable font size. Thus, implementation of argument or concept mapping to mobile devices is more challenging.

5 Conclusion

The study has shown that critical thinking can be enhanced or enabled by different kinds of methods and tools in e-learning. These methods and tools enhance or enable critical thinking in different ways. A model for critical thinking in e-learning can be constructed based on this study and it goes in the following way: Different learning strategies enhance critical thinking in different ways. Different learning strategies are used in different learning tools. These learning tools can then be implemented to e-learning.

In order to make conclusions on how critical thinking can be enhanced in e-learning, we first investigated which learning strategies could be used. Then we explored which tools use these learning strategies. Only once we knew which learning tools are relevant to critical thinking, were we able to study how they have been and can be implemented to e-learning.

5.1 Enhancing and enabling critical thinking in e-learning

We studied how different learning strategies that are either cognitive, metacognitive or resource management strategies relate to critical thinking. Table 2 below illustrates how these learning strategies relate to critical thinking and whether they are cognitive, metacognitive or resource management tools.

Table 2 - Learning strategies and their relation to critical thinking

Cognitive/ metacognitive/ resource management	Learning strategy	Relation to critical thinking
Cognitive	Rehearsal	Does not help with understanding connections in the information, so does not enhance critical thinking. Oppositely routinization of the learning process can be disadvantageous for critical thinking.

Cognitive	Elaboration	Usually elaboration does not significantly enhance critical thinking. This is because paraphrasing, summarizing are for the most part repeating what is already known. However, when elaboration uses analogies, it helps the learner to create connections between different things, which enhances critical thinking.
Cognitive	Organisation	This can help with understanding the bigger picture and connections in the information that is to be learned enhance and enable critical thinking.
Metacognitive	Planning strategies	Planning strategies do not have a straight relation to critical thinking. This is because they do not focus on the content that is to be learned.
Metacognitive	Monitoring strategies	Monitoring activities might help the learner to critically think about their own learning, but usually not about the content that is to be learned.
Metacognitive	Regulating strategies	Regulative strategies have a relation to critical thinking only through monitoring strategies.
Resource management	Time Management	Resource management strategies do not enhance higher order thinking, and thus by alone do not affect critical thinking. However, they have a link to monitoring strategies which can enhance critical thinking concerning the learners' own studying process.
Resource management	Environment management	
Resource management	Support of Others	
Resource management	Effort management	

It can be concluded that cognitive strategies especially organisation and elaboration strategies are the most relevant in enhancing critical thinking. Different tools use the learning strategies summarized above. In this paper, we defined tools as instruments and devices that aid in accomplishing tasks. Tools too can be categorized in different ways, since they have both common

and different aspects. Table 3 below summarizes what kinds of tools can be used for the learning strategies and gives examples of those tools.

Table 3 - Learning strategies and tools that can be used

Learning strategy	What kinds of tools can be used? Which activities are relevant for critical thinking? Are they electronic?	Examples of e-learning tools
Elaboration	Often the same learning tools can be used for organisation and elaboration. Many of these tools are electronic and can be implemented to e-learning. Good examples of tools for this purpose are visualisation tools and discussion tools. Conversational, mapping and visualization activities are relevant. The Socratic method which we studied in detail in this research can be implemented to e-learning using conversational tools. There are many electronic tools, some mentioned in examples.	Mapping tools, discussion boards, chats, video calls, and other communication tools that allow discussion
Organisation		
Monitoring strategies	Tools that help learners to monitor their learning are usually also useful for resource management, and often in the first designed for resource management purposes. Many of these tools are electronic tools and thus can be implemented to e-learning. The tools should help the learners to evaluate and in doing so monitor their own learning, for example the depth or progress of the learning process. There are many electronic tools, some mentioned in examples.	Checklist/criterion to evaluate progress/depth of learning, studyplans, calendars

5.2 Common aspects and future research

General aspects that need to be considered in implementation of learning tools to e-learning context can be formalized, regardless of which specific tools are on hand. For conversational tools, the type of communication should be chosen carefully since it has many effects. Aspects that should be considered with communication in e-learning tools are whether the communication is to be synchronous or asynchronous, and whether it is in written or spoken form. In the case of the Socratic method, as well as other possible methods that present the learner with questions, the type of questions need to be considered. Commonly among all kinds of e-learning tools, the need for new tools and effect on motivation should be considered.

Future investigation could focus on different learning tools. In this study, we specifically addressed only the Socratic method, and concept and argument mappings, but also other named learning tools could be studied. Another aspect that could be studied in the future, is the implementation of the structure: “learning strategy -> learning activity -> learning tools -> implementation of the learning tools” to other aspects but critical thinking. Firstly, it could be studied where could this structure be used, and secondly hopefully it could then actually be used in a different context.

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